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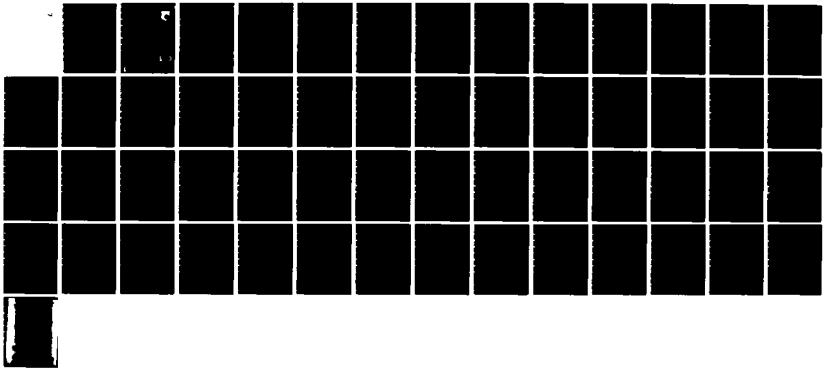

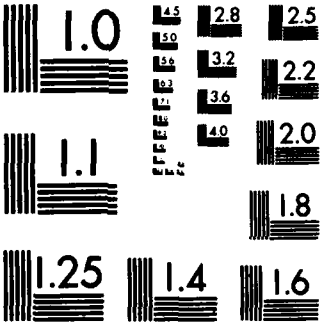

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A DATA ACQUISITION AND REAL-TIME DISPLAY SYSTEM FOR TESTING A JET ENGINE COMPRESSOR

D. S. Leonard
Technology Branch
Turbine Engine Division

AD-A142 696

March 1984

Interim Report for Period January 1980 to January 1982

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This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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A test was conducted by the Air Force Aero Prouplsion Laboratory to study the performance of jet engine compressors during engine speed transients. Effective analysis of the test results required accurate, high speed data acquisition during the transients. On-line reduction and display of the performance data was desirable to improve the efficiency of the test operations. This paper describes the software that was designed and implemented to acquire and display the performance data. The software controls data acquisition and

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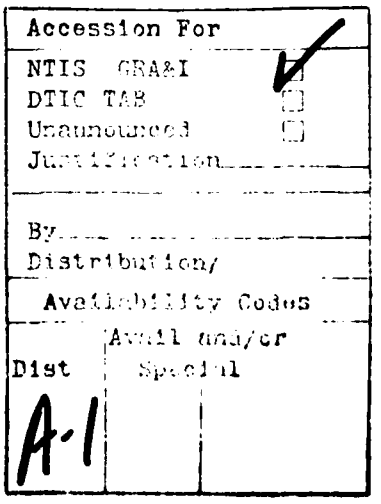
calibration equipment, provides on-line calibration of transducers, records the data, reduces and displays performance data (including graphics), and allows the test operator to control these functions.

FOREWORD

This report contains the results of a thesis which was prepared for the Computer Science Department of Wright State University. The effort was performed in the Technology Branch of the Turbine Engine Division of the Aero Propulsion Laboratory, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, under Project 3066, Task 04, Work Unit 52. Software was developed to support the compressor airflow study of this work unit. The software acquires compressor performance data by controlling data acquisition equipment, displays the data in real time, and records the data. This effort was conducted by Donald S. Leonard during the period of January 1980 to January 1982.



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SECTION I

INTRODUCTION

This report describes a data acquisition and display system to support a jet engine research test. The engine to be tested is mounted on a test stand and is controlled by a computer. Instruments have been installed on the engine so that performance data can be acquired by another computer. When the test operator commands it, the data acquisition computer controls the instruments, reads the data, and records the data. Some of the data is displayed on CRTs so that test engineers can monitor them. The recorded data is taken to another computer, which uses the data to analyze the engine performance.

The test article is a jet engine that is instrumented for measuring engine RPM, mass flow, temperatures, pressures, air velocities (direction and speed), and clearance between compressor blades and engine case. A Preston High Performance Data Acquisition System (HPDAS) is used to acquire most of the data. An HP period meter measures engine period for calculating RPM. A clearance measurement system, temperature thermocouples and pressure transducers measure their respective parameters. Calibration equipment is used to calibrate pressure transducers while the test is running.

The tests will investigate performance of the engine's compressor section at steady-state and during speed transients. Steady-state data points are acquired after setting the engine at a particular speed and monitoring the data until all parameters have stabilized. The data is then acquired and recorded. By varying certain engine controls and taking steady-state points, the steady-state performance range can be determined for a given speed. These points form a "speed line".

SECTION II

SOFTWARE REQUIREMENTS

1. SOFTWARE REQUIREMENTS

The software must accept operator commands from a CRT and execute the commands. It is required to control all of the data acquisition equipment and acquire performance data. This data acquisition must be synchronized with the engine speed. The data is then recorded onto magnetic disk and later copied across a data link to the host computer, where the data is stored on magnetic tape. Some of the data in memory is used for calculating engineering units, which is displayed on the CRT. The CRT display can be hardcopied on a printer. Graphics are displayed using the engineering units data on a graphics CRT. The software is required to perform on-line calibration by controlling the calibration equipment, reading and recording the data and calculating new coefficients for the parameters that are displayed. During initialization, the software will need to read and record tables, including calibration coefficients, test configuration, and other information.

2. AVAILABLE SOFTWARE TOOLS

The computer used for data acquisition and data display is a Modcomp Model II/45. It uses Modcomp's MAXNET III Operating System. MAXNET III is an extension of MAX III, with network communication software.

MAX III is a task-oriented multiprogrammable operating system. Context switching is triggered by "events." An event may be a completion of a delay service, an I/O interrupt, voluntary relinguishing by a task, or a change in a bit or word in memory. Tasks are scheduled by the priority that is assigned to each. MAX III provides executive services, such as task control (activate, hold, resume, abort, etc.), I/O services, and utility services (time and date, etc). I/O operations in MAX III may be performed in quick return mode, where I/O is concurrent

with the initiating task, or in wait mode. The OS provides global common that can be shared by all tasks. MAX III includes a macroassembler and a FORTRAN IV compiler. "Netdevices", such as the tape drives and printers on the Host computer, can be accessed through MAXNET III as though they were local devices.

A system library is available that includes software, such as routines for accessing MAX III executive services, for arithmetic, logical, and bit manipulation, and Tektronix's TCS library for graphics support.

Another software tool available is the core device. This is used internally by the MAXNET link software, but is also available to application software. The core device is used like any real device, but data is transferred to and from a buffer in main memory. This tool is very useful in data conversion. For example, data can be written to the core device in ASCII and read back using integer or floating point format conversions. The buffer is 128 words long. I/O always starts at the beginning of the buffer, so a rewind is meaningless. The buffer will not allow two consecutive writes without a read in between. The task initiating the second write will hold until another task reads the buffer. MAXNET uses this feature for process synchronization. A task using this tool for data conversion must ensure that the core device is dedicated to it. Before using the core device, the task should perform a dummy read to clear any write that may have occurred previously.

SECTION III

HARDWARE

This chapter describes the equipment used by this system. Figure 1 is a logical diagram showing the information flow between the computer and the equipment.

1. COMPUTER

The central processor is a Modcomp Model II/45 made by Modular Computer Systems. It is a 16-bit processor with 64K words of memory. It has a Direct Memory Access (DMA) processor capable of 800 kw/sec aggregate data rate. The DMA is used for disk I/O, High Performance Data Acquisition System (HPDAS) data acquisition, and data link transfers. The disk is a Modcomp Model 4132, which has a 12.5 MW capacity with a transfer rate of 150 kw/sec. The data link is a serial full-duplex synchronous link with a data rate of 125 kw/sec. An I/O Interface Subsystem (IOIS) is used for digital I/O. A 1200-baud terminal keyboard printer is used for small print-outs and event logging. The system includes an ADDS 580 A/N CRT and a Tektronix 4010 graphics CRT, which both operate at 9600 baud. The data link is used to communicate with another Modcomp system which includes magnetic tapes and high-speed printers.

2. DATA ACQUISITION SYSTEM

Analog data is acquired using the Preston High Performance Data Acquisition System (HPDAS). The HPDAS uses an Analog-to-Digital Converter (ADC), with a 14-bit+ sign output and 400 KHZ maximum conversion rate. The ADC input comes from 128 channels through a 128-to-1 multiplexer. These 128 channels are outputs of 128 amplifiers. The amplifier gains and filters can be programmed by the Modcomp. The channels can be sampled sequentially or in random order. An important feature of the HPDAS interface is the "external sync" mode. In this mode, the Modcomp initiates a read, but no data is transferred until the HPDAS is triggered by a pulse from an external input. The HPDAS also has a channel check feature for on-line calibration of the amplifiers.

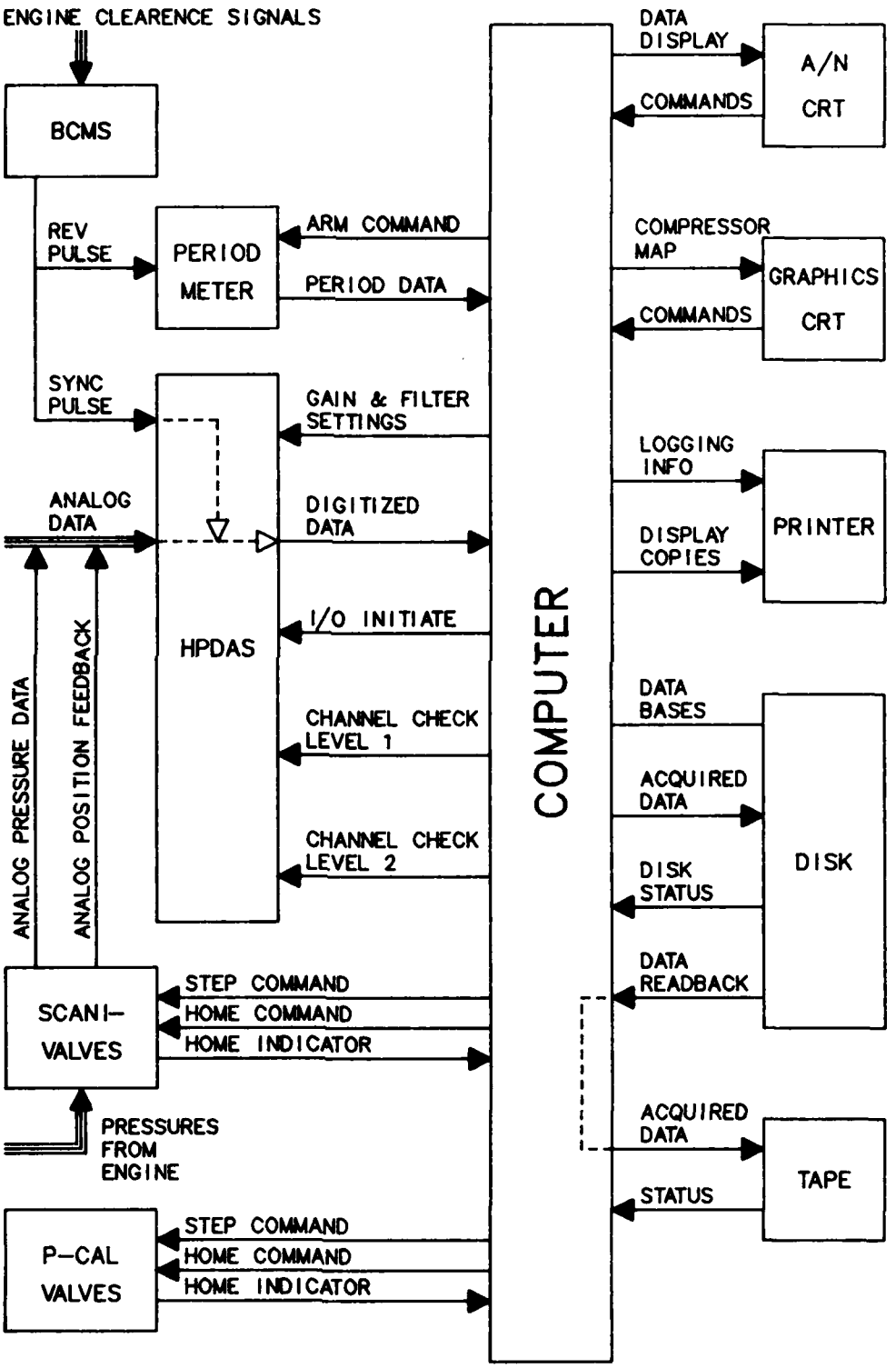

Figure 1. Information Flow

This is done by switching the inputs of the amplifiers between two known high-precision reference voltages.

3. FACILITY

The facility includes two rooms: the test cell and the control room. The control computer and the data acquisition computer are located in the control room. The test cell contains the test article chamber. The test article is a General Electric J85 gas turbine engine. It is instrumented with pressure transducers, thermocouples, clearance probes, air velocity probes, and various position indicators. Next to the chamber is a thermocouple reference junction box, which is kept heated to 150°F. The pressure transducers require reference pressures. Several highly accurate reference pressures are provided in the test cell using Ametek dead weight testers. Two of the dead weight testers are located in a vacuum box so that they can supply lower-than-ambient pressures. The box is pumped down using vacuum pumps. Digital signals from the reference pressure system that are read by the Modcomp I/IOIS system indicate the integrity of the box vacuum and the reference pressures.

4. BLADE CLEARANCE MEASUREMENT SYSTEMS (BCMS)

The purpose of the BCMS is to measure the clearance between the compressor blades and the engine casing and to determine the amount of case distortion. These clearances are typically .005 to .050 inch. The clearance transducers are probes mounted in the engine casing. These probes are variable capacitance devices in which the capacitance value varies inversely with the blade tip-to-probe clearance. Signal conditioning equipment converts the capacitance value into voltage to be measured by the HPDAS. Synchronization of the BCMS with the engine rotational speed is required. To accomplish this, one compressor blade was shortened by .005 inch. A synchronization circuit outputs a pulse as this blade passes one of the clearance probes. This once-per-engine-revolution pulse signal is used to synchronize the BCMS circuitry and also to trigger the HPDAS data transfer to the computer. The period of this signal is measured so that engine RPM can be calculated.

5. PERIOD METER

A Hewlett Packard 5328 Period Meter is used to measure the period of BCMS synchronization signal. The resolution of this meter is 10 nsec. To achieve the most accuracy, the meter must be "armed" before taking a measurement. The computer arms the meter by outputting an arm pulse. The meter then measures the next two BCMS pulses. The meter must be armed before each measurement. This allows only one measurement every two pulses (or every two engine resolutions).

6. SCANIVALVE

This facility uses four Scanivalves for steady-state data acquisition. The Scanivalve is a device that allows measurement of a large number of pressures with a single transducer. Figure 2 shows one Scanivalve. Each Scanivalve multiplexes 48 pressure ports to one by rotating a valve among the 48 input ports. All four valves are mechanically linked together to rotate simultaneously. Because they involve mechanical rotation, the Scanivalves are only used for slow changing pressures. They are controlled by giving them a "step" pulse, which moves them to the next port, or by a "home" pulse, which moves them to a port designated as "home" port. A contact-closure feedback indicates that the valves are at home port. An analog feedback gives position in terms of voltage from a potentiometer. This position feedback can be calibrated by homing the valves and stepping to the first port. The home position is the highest voltage, VH, and the first port position is the lowest, VL. The potentiometer is linear, so each remaining step is an equal portion of the difference; Vstep = VH-VL divided by 47.

7. PRESSURE CALIBRATION

Pressure calibration hardware is used for the three types of pressure transducers used in this facility. The three types are high-response, close-coupled and steady-state.

a. The steady-state transducers are the ones that measure Scanivalve data. Typically, a long pressure tube carries the pressure

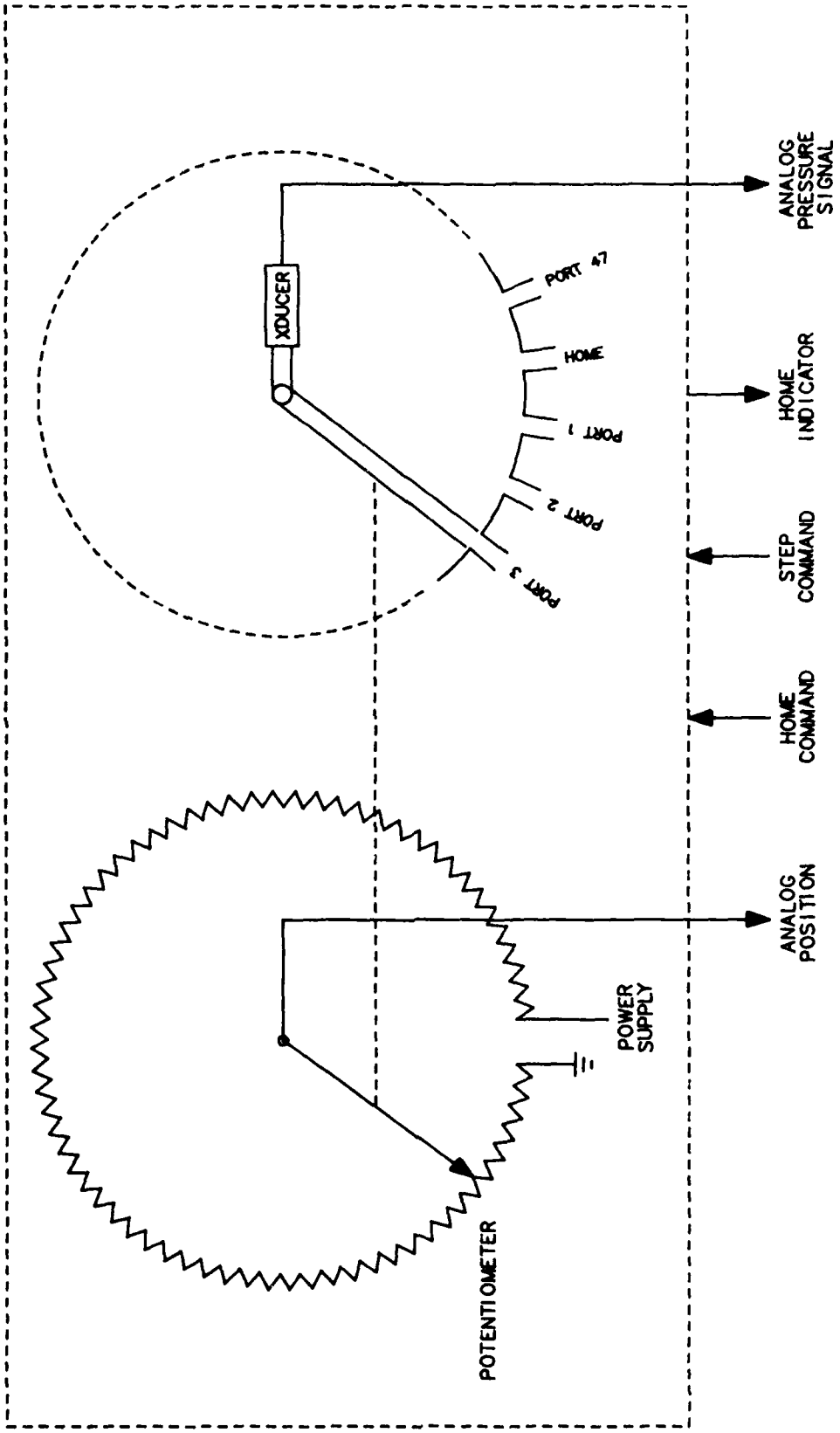

Figure 2. Scanivalve

from the location to be measured. If the measured pressure changes, time must be allowed for that new pressure to stabilize throughout the length of the tube, so quickly changing pressures cannot be measured accurately. Known reference pressures are plumbed to ports on the Scanivalves so when those ports are measured, during each Scanivalve rotation, the data can be used for calibrating the transducers.

b. The high-response transducers are mounted in the compressor case so they can measure quickly changing pressures. Each high-response transducer is mounted close to a probe that is plumbed to a Scanivalve port. Before and after an engine speed transient, the scanivalve ports are measured. Because the Scanivalve data can be calibrated each rotation, the probes give accurate values of the initial and final pressures of the transient. These values can then be used to calibrate the high-response transducers during the transient.

c. Close-coupled tranducers are used for measuring slowly changing pressures. A short tube carries the measured pressure to the transducer. A pressure calibration (P-CAL) valve can switch the transducer from this measurement tube to a calibration pressure (Figure 3). The P-CAL valve's operation is similar to the Scanivalve's, but it switches a number of transducers between two ports, measurement and calibration. A home indicator indicates which port it is on. The valve is controlled by a step command and a home command. The calibration pressure can be switched between two known pressures by opening and closing solenoid valves to those pressures so that the transducers can be calibrated using measurements taken at each pressure.

The solenoid valves can be set to three positions (Figure 3).

(1) Valves 1 and 2 open; valve 3 closed: Each transducer measures the difference between 14 psia and 14 psia (zero).

(2) Valves 1 and 3 open; valve 2 closed: Each transducer measures the difference between 14 psig and 10 psig.

(3) Valves 2 and 3 open; valve 1 closed: Each transducer measures the difference between 10 psig and 10 psig (another zero)

Discrete feedbacks from the Reference Pressure Supply System indicate the credibility of these reference pressures.

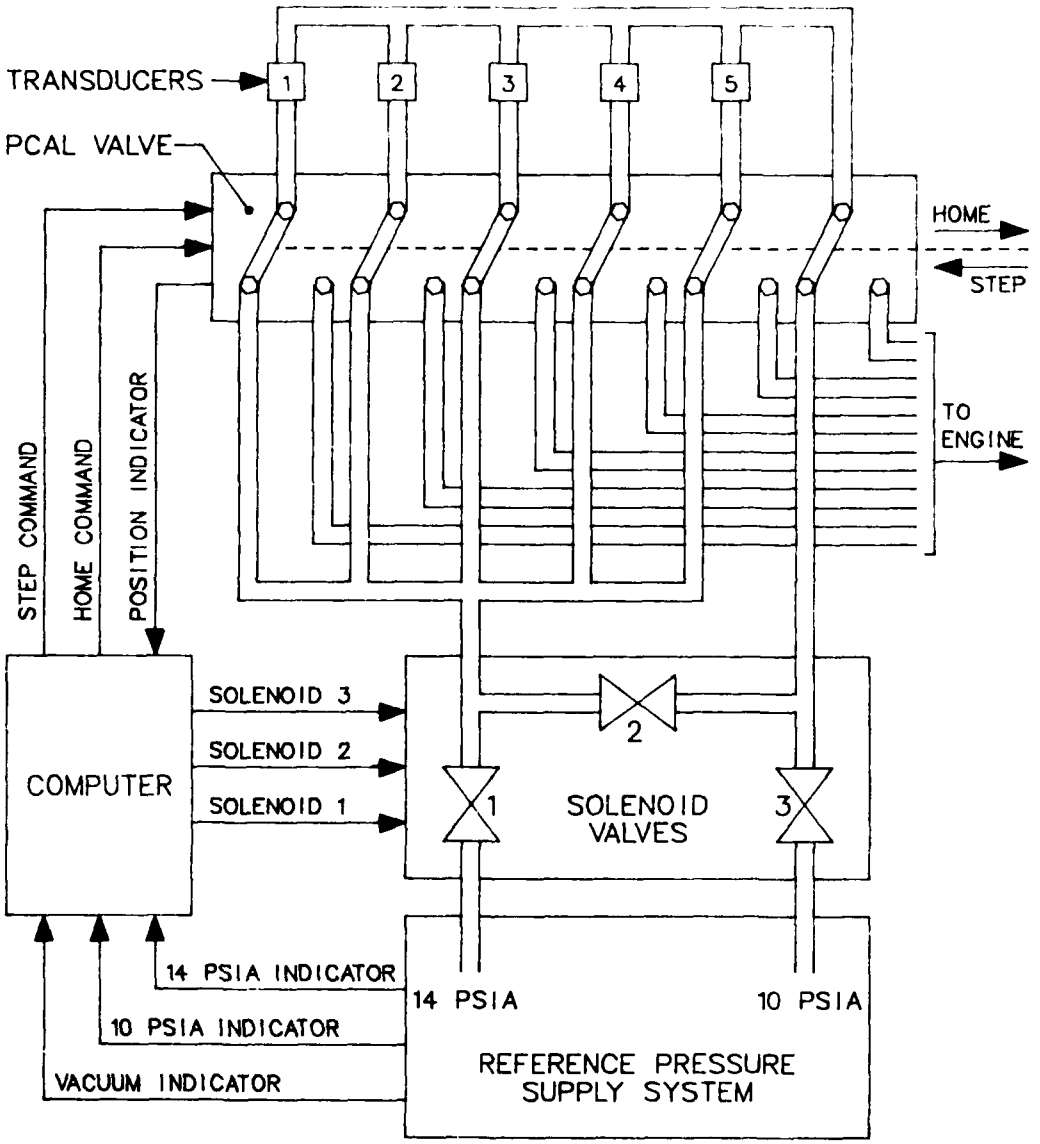

Figure 3. P-CAL Valve

SECTION IV

SOFTWARE DESCRIPTION

This chapter describes the functions of the software that was developed for this system. It begins by discussing the types of data acquisition and the recording of this data. It describes the operator interaction and the control of equipment. Finally, it talks about the tasks that are used to perform these functions, and how the tasks communicate with each other.

1. DATA MONITORING

During a large portion of a test, data needs to be acquired and displayed, but not recorded.

2. STEADY-STATE DATA ACQUISITION

The Scanivalve is rotated and at each port, all data is read and averaged. The averages and standard deviations are recorded.

3. TRANSIENT DATA ACQUISITION

Transient data acquisition consists of a sequence of six functions.

a. Transient-Cal-1: The high-response pressure transducers require calibration measurements before and after the speed change. The first is the Transient-Cal-1. The transient calibrations are functionally the same as steady-state acquisition.

b. Transient-1: This acquires and records data at a high rate while engine speed is changing.

c. Transient-2: This records data at a lower rate after the engine speed has reached its destination but other engine parameters are stabilizing.

d. Transient-Cal-2: When reference pressures for high-response transducers have stabilized, the second set of calibration measurements are taken.

e. Transient-3: This is a continuation of Transient-2.

The data acquisition rates and durations of the transients are entered by the data engineer before the transient.

4. CALIBRATION

a. On-line calibration can be performed on all of the pressure transducers and on the HPDAS amplifiers. The calibration of the high-response transducers is done with Transient-Cals. The close-coupled transducers are calibrated using the P-CAL valves. The steady-state transducers, which are used to measure the Scanivalve ports, are calibrated using reference ports on the Scanivalves that are measured each time the Scanivalves are rotated.

b. THE HPDAS amplifiers are calibrated with channel check hardware that is part of the HPDAS.

5. OPERATOR COMMANDS

The data engineer is able to control the data acquisition by entering commands into the A/N CRT. The software ensures that commands will not be accepted in an improper sequence. For example, a calibration command will not be accepted while transient data is being acquired.

6. DATA DISPLAY

Certain compressor performance parameters are calculated from the acquired data. These parameters and some facility information are displayed on the A/N CRT. Calibration coefficients of these facility parameters are recomputed during each on-line calibration. A compressor map can be plotted on the graphics CRT. The test operator can use this map to easily determine where the compressor is operating on the map at any time during a test. The data engineer can receive, at his request, hardcopy print-outs of the CRTs. The graphics hardcopy uses a hardcopy device that is attached to the CRT (Figure 5). The A/N CRT must be copied using software to print to the keyboard printer (Figure 4). The A/N CRT display continues to update while the printer is printing.

```
< < < < J85 DATA ACQUISITION- AFWAL/PCTX > > > >      |14:28:11   10/14/80
                                                      |  RUN NO.      5
                                                      |POINT NO.     63
-------------------------------------------------------+-------------------+-------------------
                  ACTUAL      CORRECTED                |                   |
FLOW RATE(LB/S)     21.94        22.75                 |7TH STAGE CLEARANCE |RPR= 50 REV'S
     SPEED(RPM)   11636.    11549.   69.8%             | AVE=      22.454 MILS | TIME1=    30
     TACH.(RPM)   11653.                                |           22.024    | RPR1=     50
-------------------------------------------------------+           22.266    | TIME2=    20
                                                      |           22.860    | RPR2=    100
COMPRESSOR INPUT:    14.3 PSIA   626.DEG-R            |           22.668    | TIME3=    60
       DISCHARGE:    41.6 PSIA   730.DEG-R            |                     +-------------
  PRESSURE RATIO:     2.92                            |                     |SCNV PORT   4
-------------------------------------------------------+-------------------+-------------------
TURBINE DISCHARGE:   16.2 PSIA 1463.DEG-R             | DEVIND=001111111    |DISK   7% FULL
       ATMOSPHERE:   14.3 PSIA   68.DEG-F             | STATUS=    0 TT T   |SCTR #   4072.
-------------------------------------------------------+-------------------+-------------------
          INLET VALVE POS:    98.10 DEG.              | ONLINE= T           |RQMODE=MONITO
            IGV/BLEED POS:    91.00 %                 |                     |  MODE=MONITO
      EXHAUST NOZZLE AREA:   136.20 SQ.IN.            |                     +-------------
-------------------------------------------------------+
```

Figure 4. Hardcopy of A/N CRT

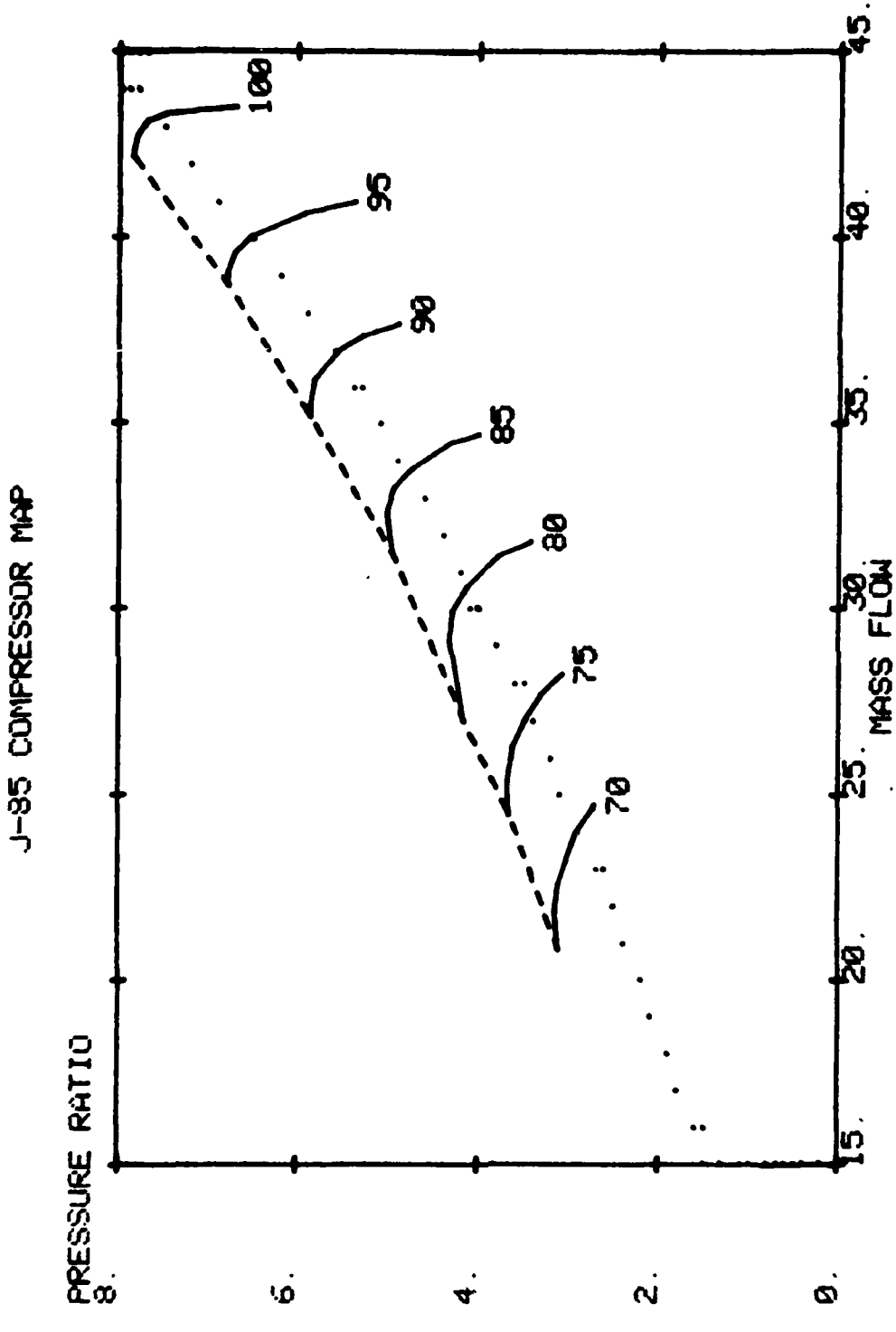

Figure 5. Hardcopy of Graphics CRT

7. DATA CONVERSION

The data for the display parameters must be converted from transducer outputs to engineering units, such as temperature and pressures.

The engine rotational speed is computed by converting the period meter input from BCD to floating point to get period in seconds, and dividing that into 60 sec/min to get speed in revolutions per minute.

Pressure calculations use linear coefficients to convert HPDAS input counts into pressure in pounds per square inch.

Blade clearances are calculated using a linear fit to convert HPDAS counts into millivolts. The millivolts are used to search the clearance tables to find clearance in mils.

The temperatures use the same method as the clearance calculations, except that the effect of the thermocouple reference junction must be considered. Thermocouple tables were developed using a zero degree reference junction. The known temperature of the reference junction is used to "look up" the reference junction voltage in the thermocouple tables. This is added to the voltage reading of the HPDAS channel, and the table is searched using the combined voltage value to find the temperature in degrees Celsius. This value is then converted to degrees Fahrenheit or Rankine, depending on the channel.

Mass flow, corrected mass flow, and corrected speed are parameters that describe the performance of the compressor. Mass flow of the engine is calculated as a function of certain pressures and temperatures. Corrected mass flow is a function of mass flow and the compressor inlet temperature and pressure. Corrected speed is computed using mechanical speed and inlet temperature.

8. GRAPHICS

The graphics give the test engineers on-line feedback of the performance of the compressor at a given time during the test. Figure 5 is a hardcopy of the graphics display. A background map is drawn initially to provide orientation. The data used to draw this map came from a simulation of the test article. Once per second, a point is output to the graphics screen to show where the compressor is now performing in relation to the map. The CRT has a storage type screen, so the point remains there. In this way, the route of the test can be followed. The display is only active in the transient and monitor modes because the required data is not acquired during calibrations, steady-state, and other modes. The data engineer can command the map software to start and stop output of the points and to redraw the background if desired.

9. DATABASE INPUT

Several databases are read from disk files when the system starts up that are either; (a) recorded for later use by data reduction program, (b) used here in the data acquisition and display software only, or (c) both used here and also recorded for later use. These databases are all in ASCII character format and, if recorded, are stored that way.

a. In the first category is a database that describes the test article configuration. It describes the location of probes on the test article, modifications that have been made to the test article, and physical characteristics of the facility that affect the test.

b. Thermocouple calibration tables are in the second category. These tables are used to convert voltage measurements into units of temperature. One table must be read for each type of thermocouple used in the facility. These tables will not change because they are characteristic of the thermocouple types, not of this facility. So instead of recording the tables here, the computer that reduces the data will have access to identical thermocouple tables.

c. The third category includes the clearance probe calibration tables. The clearance tables are similar to the thermocouple tables, except that they will change when the probes are calibrated off-line. The data reduction programs will require the latest calibration information, so the tables are recorded. For use in the display software, the tables must be converted from ASCII characters into internal computer format.

A database describing the data acquisition system is also in category 3. It contains information about each transducer used in the facility: digital or analog, channel number, HPDAS gain and filter, calibration coefficients, method for converting to engineering units, reference values for calibrations, excitation voltage if required, and text describing the transducer. The data acquisition and display software must get certain information from this table as it records it. The gain and filter for each HPDAS channel must be kept and eventually sent to the HPDAS to set up the amplifiers. The gain, calibration coefficients and excitation voltage are used, along with the conversion method for computing initial calibration coefficients for each parameter that is displayed on the CRT. The calibration reference values are used during on-line calibrations to recompute these coefficients.

10. DATA RECORDING

The acquired data that is to be recorded is stored on the magnetic disk. The data recording process should not interfere with the data acquisition process. The test operator can command the disk data to be copied to magnetic tape for permanent storage. When the disk is full, this copy is required.

11. CONTROL OF HPDAS

a. The HPDAS needs to be initially sent a gain and a filter setting for each channel and the scan mode, either immediate scan or external sync. The data engineer may also request later that gains, filters, or the scan mode be changed.

b. To acquire data, the software sends a transfer initiate command to the HPDAS. The data is transferred either immediately or after an external trigger pulse from the Blade Clearance Measurement System (BCMS).

c. The software controls the channel check function of the HPDAS at the data engineer's request. The channel check function provides data for calibrating HPDAS amplifiers. The channel check software first sets each amplifier input to level 1 (zero volts), measuring each channel and recording the measurement. Secondly, it sets each amplifier to level 2 (a known high-precision voltage), it measures the channels, and records the data. The channel check hardware is then deactivated so the channels will measure the desired engine parameters. Data from the channel check are used to compute new calibration coefficients for parameters that are displayed on the CRT.

12. CONTROL OF PERIOD METER

The period meter measures the period between pulses that are generated with each engine revolution. The meter is armed by outputting a pulse to its "arm" input. The software must then wait two revolutions before reading the meter. The HPDAS external synchronization is used for this timing because its trigger pulse is what the period meter is measuring. The software initiates two HPDAS data transfers, waiting after each for the HPDAS to respond. After the second response, two engine revolutions have occurred, so the meter can be read. This reading is in BCD format. The BCD is then converted to binary and used to calculate speed of the engine in RPM. If the HPDAS is in the immediate scan mode, the software delays before reading the period meter. This delay must be at least as long as the time required for the engine to rotate two revolutions at the engine's minimum speed.

13. CONTROL OF SCANIVALVES

Each Scanivalve rotates a pressure transducer valve to 48 ports to be measured. These ports are designated ports 0 thru 47. Port 0 is considered the home port. The software issues a home command to move the valves to port 0. The software then reads a contact that closes at

port 0 to ensure that home is reached. A step command moves the valve one port. The valves can rotate in one direction only. An analog voltage feedback on an HPDAS channel is used to determine valve position. The maximum voltage is at port 0 and the minimum is at port 1. Each step changes the feedback by an equal voltage. The position feedback is calibrated with each revolution by using the voltages measured at ports 0 and 1 to ensure credibility of the feedback. When it is desired to rotate the valves to a particular port, the software determines whether to move in steps or to home and then step. (The home command moves the valves much quicker than successive steps.) If the desired port is less than the present port, it homes the Scandivalve and then steps. If the desired port is greater than the present port, it just steps to the destination. Of course, if port 0 is the desired port, only a home pulse is required.

14. CONTROL OF P-CAL VALVES

The P-CAL valves are used to calculate the close-coupled pressure transducers. The P-CAL valves can switch each transducer between measurements and calibration ports. The software issues a home command to the P-CAL valves to switch them to the measurement ports and reads a contact that closes at home port to make sure the switch is accomplished. To move to the calibration ports, a step command is used. The contact is read here to ensure that it is open. When the transducers are in calibration position, the software uses solenoid valves to channel reference pressures to the transducers. The software reads various digital indicators from the reference pressure system to ensure that the pressures are accurate. In the calibration process, the software steps the valves to calibrate position, switches the solenoids to the first reference pressure, measures this pressure, and records the data. It then switches to the second reference pressure, measures it, and records this data. The valves are then homed for measuring engine parameters. The measured calibration data is used to calculate new calibration coefficients for pressure displayed on the CRT.

15. CONTROL OF DISK

a. Data are stored on disk in buffers of six 1/0-word logical records for timing purposes; two of these buffers are used alternately. While one is being written to disk, the other is being filled with data. The timing and buffer sizes are discussed in the next chapter. Standard Fortran I/O cannot be used because MAX III Fortran uses I/O buffers that are only 128 words long and does not support quick return I/O. Therefore, the MAX III nonstandard write service is used. This service requires the user to supply a User File Table (UFT). The UFT contains the file name and record size, and tells whether I/O is random access or sequential and whether operating system error recovery is to be used. If random access is selected, the UFT contains a pointer to the starting disk sector within the file of the I/O. Status of the I/O is returned in the UFT. This data acquisition software must use random access because sequential I/O cannot be used for records larger than one disk sector (128 words). The sector pointer is a 15-bit number or, optionally, a 32-bit double word. The testing in this facility requires more than 32K sectors, so the 32-bit option is used. The system error recovery option is not used because the operating system will attempt retries on errors. Retries can result in data being lost because the disk output may not keep up with the data acquisition. Actually, once this software became functional, a disk error was never detected except in the case of major disk malfunctions in which the disk had become nonoperational. The software keeps track of the sector pointer with a double precision floating point number. The number is incremented by six for each write. Each logical record uses six sectors. If this pointer becomes larger than the file size, then the caller is informed that the disk is full and the record will not be written. Otherwise, the pointer is converted to a 32-bit integer and placed in the UFT before the write. After the write is initiated, a buffer switch is switched so that the other buffer will begin to be filled with the acquired data.

b. When the disk file is full or when the data engineer decides, the data is copied to tape. This again uses MAX III nonstandard reads from the disk and nonstandard writes to tape. The same UFT is used for

the disk read that was used in the write. The read function is similar to the disk write, except only a single buffer is used and I/O is done in wait mode instead of quick return. The tape writes use a different UFT. Sequential I/O must be used with a tape, and tape sequential I/O will allow larger than 128-word records. Double buffering could have been used to speed up this copy process, but the timing wasn't critical so single buffering was used.

16. DEVICE STATUS

A status word in global common contains a status bit for each data acquisition device. If a device malfunctions, the software sets its corresponding bit. Each data acquisition process examines the status word before recording any data. If the status is not zero, the process is aborted and the malfunction is logged on the printer. The data engineer can also abort an executing process by entering a data abort command, which sets a data abort bit in the status word.

17. TASKS

a. The required functions are split into four MAX III tasks so that processes can perform concurrently. The tasks are the data acquisition task (J85DAQ), the operator console task (J85CONSOLE), the A/N display hardcopy task (HDCPY), and the compressor map task (MAP). The tasks communicate with each other through a global common area in memory.

(1) J85CONSOLE computes and displays compressor performance data and data system information on the A/N CRT. J85CONSOLE gets the data for computation and the data system information from J85DAQ through global common. J85CONSOLE reads and processes data engineer commands from the A/N CRT keyboard. It controls the J85DAQ and HDCOPY depending on these commands.

(2) J85DAQ acquires data using the acquisition mode requested by J85CONSOLE and records the data as requested. J85DAQ controls all the data system equipment, such as P-CAL valves, Scanivalves, period meter, HPDAS, disk, and tape.

(3) HDCOPY prints display data that has been copied to global common by J85CONSOLE. This allows J85CONSOLE to simultaneously update the CRT with new data.

(4) The MAP task displays compressor performance information of the graphics CRT that was calculated by J85CONSOLE.

b. Modes

J85CONSOLE controls J85DAQ by setting a requested mode word in global common. J85DAQ responds by setting the mode word in global common to that requested mode and performing the function of that mode. The modes are as follows:

MONITOR - Acquires data but does not record any

TRANSIENT CAL1 - Reads Scanivalve to get initial reference pressure for calibrating high-response transducers before a transient

TRANSIENT CALI WAIT Mode - Pauses after TRANSIENT CAL1 to allow the operator to synchronize the data transient with the engine transient. A "GO" command on the console will start the TRANSIENT 1 mode.

TRANSIENT 1 - Acquires data during engine speed transients

TRANSIENT 2 - Acquires data during transients after TRANSIENT 1 completes, usually at a slower data rate

TRANSIENT CAL2 - Reads Scanivalve to get final reference pressures for calibrating high-response transducers after TRANSIENT 2

TRANSIENT 3 - This is a continuation of TRANSIENT 2. A TRANSIENT CAL2 is performed between TRANSIENTS 2 and 3.

CAL MODE - Performs a channel check on the HPDAS and a P-CAL on all the close-coupled pressure transducers

STEADY-STATE - Rotates Scanivalves, acquires and records all HPDAS channels while at each port

DISK-FULL-MODE - Disk is full.

DISK-TO-TAPE - Copies the disk data onto magnetic tape. Must be done when disk if full. Can be requested also in MONITOR or IDLE mode.

OFF-LINE - Sets HPDAS to immediate scan mode

ON-LINE - Sets HPDAS to external sync. (Data transfer from HPDAS to computer is triggered by a revolution pulse from the engine.)

LABEL - Allows operator to type a label, a four-line (80 characters each) comment, onto the CRT console. The label is recorded on disk.

ENVBLK - The Environmental Block is read from a source file on disk. The Environmental Block consists of a Data Acquisition System Data Base, a Test Article Definition Data Base and clearance probe calibration tables. From the Data Acquisition System Data Base, the following are taken: HPDAS gains and filters, deleted channel numbers, and calibration values for the data displayed on the console. The Environmental Block is then written onto the disk data file.

GAIN FILTER MODIFICATION - Records HPDAS gains and filters and deleted channel buffer (which have just been modified by the Console Program) and SETS the HPDAS

IDLE - Does nothing

STOP - Writes remaining data onto disk and stops program execution

c. Commands

The data engineer controls the tasks by entering commands to the CRT keyboard. These commands are as follows. (Only the first six characters are required.)

LABEL - Requests LABEL mode

ENVIRONMENT - Requests ENVIRONMENT BLOCK mode

MONITOR - Requests MONITOR mode

OFFLINE - Requests OFF-LINE mode

ONLINE - Requests ON-LINE mode

IDLE - Requests IDLE mode

CALIBRATE - Requests CAL mode

STEADY - Requests STEADY-STATE mode

TRANSIENT - Requests TRANSIENT sequence: TRANSIENT CAL1, TRANSIENT 1 TRANSIENT 2, TRANSIENT CAL2, TRANSIENT 3

SETPARMS, I, J, K, L, M - Sets the parameters for transient data acquisition

I = TIME1 (duration in seconds of TRANSIENT 1)

J = RPR1 (engine revolutions per recording for TRANSIENT 1)

K = TIME2 (duration in seconds of TRANSIENT 2)

L - RPR2 (engine revs per recording of TRANSIENTS 2 and 3)

M = TIME3 (duration in seconds of TRANSIENT 3)

GO - After a TRANSIENT CAL1, the TRANSIENT CAL1 WAIT mode is entered so that the data transient can be synchronized with the engine transient. The GO command then starts the TRANSIENT 1.

ADVANCE - During TRANSIENTS 1, 2, or 3, advances to the next mode in the transient sequence without waiting the required duration from TIME1, 2 or 3, respectively.

HARDCOPY - Copies CRT console display onto the printer

DISKTOTAPE - Copies the disk data file to magnetic tape

STATUS - Clears the status flags

DISPLAY - Clears the console CRT and redisplays it in case the display has been garbaged up

DABORT - Sets the data abort flag in the run status word of the data buffer. J85DAQ will the abort the current data acquisition mode and then record the abort on disk.

RABORT - Sets the run abort flag in the run status word of the data buffer. The current data acquisition mode will not be aborted, but the run abort will be recorded on disk.

RAWDATA - Prints information about console data: channel number, raw data and calculated data

STOP - Stops J85DAQ

BYEBYE - Stops J85CONSOLE

RESTART - Restarts J85DAQ. Usually only used during debugging.

CHANNELMOD - Allows operator to interactively modify HPDAS gains and filters and the deleted channel buffer. It then requests Gain-Filter Modification Mode.

J85CONSOLE ensures that an improper sequence selected by the data engineer is not allowed. For example, STEADY-STATE mode cannot be requested during a transient mode.

18. DATA STRUCTURES

The logical records that are recorded on disk are either a character type record or a data type record (Figure 6). The character type is used to record databases, tables, and labels. A data type record contains one scan of data acquired during testing.

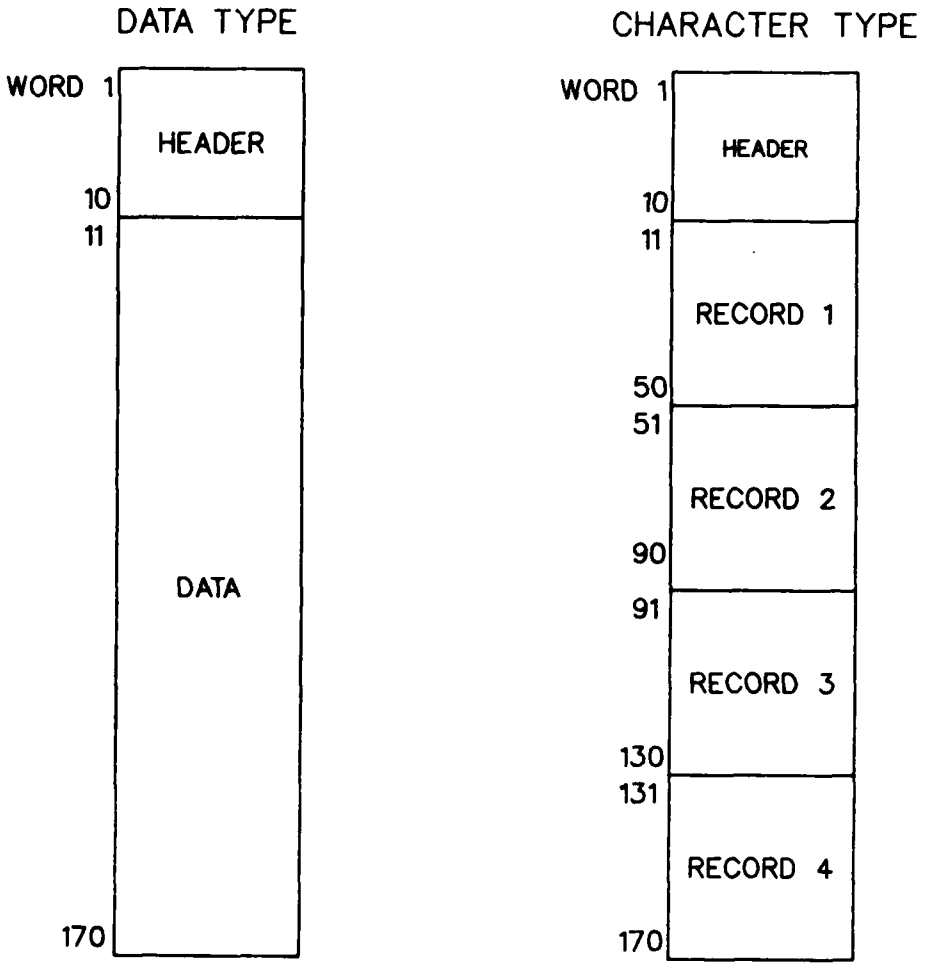

Figure 6. Record Structure

a. Header

Each type includes ten words of header information at the front of the record as follows:

word 1 - file number

word 2 - record number

words 3-8 - time and date

word 9 - record type
word 10 - record length

(1) The file number is incremented before each transient.

(2) The record number is incremented for each record that is recorded.

(3) The record type is a code for the type of information recorded in this record:

0 - Label (entered by data engineer)

1 - Data acquisition system description

2 - Test article configuration

3 - Calibration tables

4 - Data

5 - Deleted channel buffer

b. Character Type

A character type record contains four ASCII card image records of 80 characters each. The size of the character type record, including the 160 words (320 characters) and the ten-word header, is 170 words.

c. Data Type

A data type record is also 170 words, including the ten-word header and 160 words of data. The 160-word data portion is formed as follows:

Word 1 = Data Type

Word 2 = Sequence Number

Word 3 = Run Status

Word 4 = Point Number

Word 5 = Port Location of Scanivalves

Words 6-10 = Unused

Word 11 = RPR (Revolutions per Record)

Word 12 = Device Status Indicators

Words 13-15 = Period Meter Data

Words 16-32 = Unused

Words 33-160 = HPDAS Data

(1) The data type is a code describing the data being recorded:

0 - Gain codes
1 - Filter codes
2 - Channel check
3 - Pressure calibration
4 - Steady-state
5 - Transient Cal 1
6 - Transient Cal 2
7 - Transient 1
8 - Transient 2
9 - Transient 3

(2) The sequence number is used to sequentially number each record as it is recorded.

(a) For Channel Check:

0 = Low reference average

1 = Low reference standard deviation

2 = High reference average

3 = High reference standard deviation

(b) For Pressure Calibration

0 = 1st position average

1 = 1st position standard deviation

2 = 2nd position average

3 = 2nd position standard deviation

4 = 3rd position average

5 = 3rd position standard deviation

(c) For Steady-State and Transient Cals:

0 = average

1 = standard deviation

(d) For transients, the sequence number is incremented for each recorded data scan.

(3) The run status indicates the following:

0 = Normal status

1 = Run abort; data is questionable but acquisition continuing

2 = Data abort; acquisition mode halting abnormally

(4) The point number is incremented for each data type that is recorded and reset to zero at the start of a transient.

SECTION V

DESIGN CONSIDERATIONS AND SPECIAL PROBLEMS

1. DISK I/O TIMING

Before designing the disk recording software, the timing of the acquisition sequence was experimented with to ensure that all data could be recorded every two engine revolutions as required. SIMDAC, a program to simulate the data acquisition sequence was written. It acquires HPDAS data in the external sync mode using a signal generator to simulate the engine once/rev pulse and records the data on disk in quick return mode. If the disk has not completed the previous output, a "MISS" counter is incremented.

```
PROGRAM SIMDAC
MISS=0
SET HPDAS TO EXT. SYNC MODE
FOR 1 SEC,DO
     ARM PERIOD METER
     READ HPDAS (waits for rev pulse)
     READ HPDAS (waits for rev pulse)
     IF DISK BUSY
          MISS=MISS+1
          ELSE WRITE TO DISK(QUICK RETURN)
     REPEAT
PRINT MISS,DATA(from HPDAS)
END
```

The engine is rated for a maximum of 16,500 rpm, or 275 hz. 285 hz was used as criterion for acceptance. Using this frequency, there were 100 misses out of 142 disk attempts. At 100 hz, there were 15 misses out of 50 tries.

At this point, the Modcomp specifications for the disk were looked up [3, pg 27-2]

Average rotational latency = 12.5 ms

Maximum rotational latency = 25 ms

Single cylinder head seek = 8 ms

Transfer rate = 150 kwds/sec

Since the disk will be dedicated to this data system, the most head movement will be one cylinder. Transfer time is 170 wds/150 kHz = 1.13 ms. Operating system I/O overhead is 1.32 ms per write [4, pg 28].

Worst case = Max latency + headseek + transfer time + overhead

= 25 ms + 8 ms + 1.13 ms + 1.3 ms

= 35.43 ms

The data needs to be recorded every two revolutions (2 revolutions/285 hz = 7.0 msec). If the data is blocked by five logical records per physical record (170 wds x 5 = 850 wds):

Transfer time = 850 wds/150 hz

= 5.67 ms

Worst case = 25 ms + 8 ms + 5.67 ms + 1.3 ms

= 39.97 ms

Required time = 7.0 ms/rev x 5 ms

= 35.0 ms

The worst case of 39.97 ms is larger than the required time of 35.0 ms, so five won't work. Blocking by six was tried:

Transfer time = 1020 wds/150 hz = 6.8 ms

= 6.8 ms

Worst case = 25 + 8 + 6.8 + 1.3

= 41.1 ms

Required time = 7.0 x 6

= 42.0 ms

The worst case is smaller than the required time, so blocking by six should work. SIMDAC was changed to double buffer and block the records. Using a blocking factor of 5, there were occasional misses. Blocking by six, MISS always resulted as zero, as expected.

Using a blocking factor of 6, the physical record size is 170 wds x 6 = 1020 wds. Each disk sector is 128 words, so the record takes eight sectors (1024 words), wasting only four words in sector 8. This makes it a convenient record size to use. Before each write to the disk, the starting sector pointer must be incremented by eight sectors.

2. DATA ENGINEER'S DISPLAY

The A/N CRT will be used for a data display and for command input. The display needs to be updated once per second or at an appropriate interval. Between updates, the operator will be able to enter commands.

The CRT has cursor addressing capability which, given the screen coordinates, can position the cursor before a read or write operation. The software will output the data headings once, and on each update, position the cursor to each heading to display the value of its associated variable.

As an experiment the following program was written:

```
PROGRAM J85CONSOLE

WRITE HEADINGS TO CRT

BEGIN LOOP

    CREATE SIMULATED DATA

    DISPLAY DATA USING CURSOR ADDRESSING

    CALL COMMAND (0)
    DELAY INTV length of time

    CALL COMMAND (1)

    REPEAT
```

```
END
SUBROUTINE COMMAND (c)
IF C=0
     READ COMMAND (QUICK RETURN)
     RETURN
ELSE
IF READ NOT COMPLETE
     TERMINATE READ
     RETURN
ELSE
PROCESS COMMAND
RETURN
END
```

There wasn't enough time for the operator to type in a command before the READ was terminated, so the quick-return READ was changed to read only one character. When that READ is completed, another READ reads in the command in wait-mode. Subroutine COMMAND was changed to the following:

```
SUBROUTINE COMMAND
     IF C=0
          READ ONE CHARACTER (QUICK RETURN)
     ELSE
     IF READ NOT COMPLETE
          TERMINATE READ
          RETURN
     ELSE
     READ COMMAND (WAIT MODE)
     PROCESS COMMAND
     RETURN
     END
```

The INTV delay time will be adjusted so that the CRT will update once per second or at an interval the data engineer is comfortable with.

3. DEBUG TOOL

Debugging real time software can be very complicated. A tool that helped in many situations prints the name of each subroutine when it is called. This tool is much more useful if it can be activated without shutting down and recompiling, etc. To do this, a MAX III null device I/O feature of assigning a Fortran Logical Unit Number to "NO" was used. If an output unit is assigned to NO, the I/O proceeds normally, except the final data transfer to the null device does not occur. A read operation is similar, except that an end-of-file condition is indicated. Using this feature, a subroutine can be coded this way:

```
      SUBROUTINE ABC
      WRITE(27,100)
100   FORMAT('ENTERING SUBROUTINE ABC')
      READ(26,101)IDUM
101   FORMAT(A1)
      Subroutine body
      END
```

If units 26 and 27 are assigned to NO, the tool is not active. If 27 is then assigned to the printer (by a MAX III operator command), the message will be printed. If 26 is also assigned to the printer, the subroutine will hold until a character is entered on the keyboard so that conditions can be investigated.

The J85DAQ task has many time critical routines. Because the null device I/O consumes operating system overhead time, the null device operation is not allowable when the tool is deactivated. Instead, time critical routines are coded this way to bypass the null I/O operation.

```
      SUBROUTINE ABC
      IF(DEBUGFLAG)
          WRITE(27,100)
```

```
100       FORMAT('ENTERING ABC')
          READ(26,101)IDUM
101       FORMAT(A1)
      Subroutine body
      END
```

DEBUGFLAG is set during IDLE mode in another routine using the null device feature:

```
      READ(24,100,END=10)IDUM
100   FORMAT(A1)
      DEBUGFLAG=.TRUE.
      GO TO 20
10    DEBUGFLAG=.FALSE.
20    CONTINUE
```

If unit 24 is assigned to NO, the read detects the end-of-file condition and sets the flag false. If 24 is assigned to an input device, the read operation will complete and the flag is set true. When another mode is selected, the debug tool will be active.

4. OFF-LINE MODE

The Off-line mode was added to this system because sometimes the trigger pulse for the HPDAS was not working, but testing was necessary anyway. The Blade Clearance Measurement System, which supplies the once-per-rev trigger pulse, uses advanced techniques that are not as reliable as fully developed systems usually are. The OFF-LINE mode sets the HPDAS to immediate scan mode, and data acquisition is no longer synchronized with the engine revolutions.

The trigger pulse would sometimes fail during a test, so an HPDAS I/O would be initiated, but because of no trigger pulse, the J85DAQ task would hang. Fixing this problem involved modifying the operating system device handler. The handler (which becomes part of the J85DAQ task)

initiates the HPDAS I/O, sets an I/O busy bit, and relinquishes until that bit is reset. The interrupt routine in the handler, which is activated when the data transfer completes, resets the I/O busy bit and forces an operating system context switch. This resumes the J85DAQ task. The handler was modified so that the calling routine supplies the word containing the I/O busy bit. A word in global common was used so that J85CONSOLE would have access to it. The J85CONSOLE OFFLINE command now requests the off-line mode and clears the I/O busy bit. J85DAQ now resumes. It sets the HPDAS to immediate scan and rereads it because the previous read ended before data could be transfered.

5. ENGINE OPERATOR'S SPEED DISPLAY

Compressor performance analysis requires many points to be acquired at the same corrected speed, but the engine controller controls the actual speed not corrected speed. For these tests, the speed was controlled manually by the engine operator. He could not see the A/N CRT from his station, so he controlled the speed using verbal feedback from the data engineer. This was difficult and very inefficient, so a BCD display panel was installed at the operator's station. J85CONSOLE now calculates the percent of maximum corrected speed and displays it on this panel. This considerably improved the speed control efficiency.

6. P-CAL VALVE RETRIES

The P-CAL valves would occasionally stick while tryinq to move to the step position. The problem appeared to be a lube oil temperature problem. When a valve would fail, a technician would manually home and step the valve several times, and this would usually clear up the problem. The P-CAL control was changed so that on a failure, it would try to home and step the valves until they stepped successfully. After five failures, it would declare a bad status and abort the P-CAL. Usually, after two or three tries, the valves would move correctly.

7. RAW DATA PRINT-OUT

While running a test, occasionally the value displayed for a parameter was obviously in error. These errors are usually either a malfunction of the transducer, cable, or HPDAS channel, bad calibrations,

or improper conversion to engineering units. To assist in isolating the problem, the RAW command was added to print out the raw (preconverted) data, the HPDAS channel number (for analog data), and the converted data for each display parameter. The coefficients for the display parameters are printed at initialization and after each calibration. The RAW printout often improved the debugging process.

SECTION VI

DESCRIPTION OF INDIVIDUAL MODULES

This chapter briefly describes each software module of this system. The purpose of the module is given first. Then, on many of the modules, the logic flow is shown in an English type language.

1. J85DAQ TASK

J85DAQ - main module for data acquisition task

```
INITIALIZE VARIABLES
LOG START-UP
LOOP
    PERFORM REQUESTED MODE
    REPEAT
```

TRNST - called for transient modes

```
LOG START OF TRANSIENT
LOOP
    LOOP RPR TIMES (RPR IS REVOLUTION PER RECORD; SET BY DATA
    ENGINNEER)
        ACQUIRE DATA
        END
    RECORD DATA
    RETURN IF MODE OR REQUESTED MODE CHANGE
    REPEAT
```

DAQSEQ - data acquisition sequence

```
LOOP
    ARM PERIOD METER
    ACQUIRE DATA
    IF EXTERNAL TRIGGER NOT ONLINE, CALL DELAY SERVICE TO
    RELINGUISH CPU TO LOWER PRIORITY TASKS.
```

```
          IF ONLINE, ACQUIRE DATA AGAIN
          IF MODE DID NOT JUST CHANGE TO OFFLINE MODE
               READ PERIOD METER
               READ DIGITAL INPUTS
               UPDATE INFO PORTION OF BUFFER
               RETURN
          SET HPDAS TO IMMEDIATE SCAN MODE
               REPEAT
ARMPM - outputs arm pulse to the period meter
JSCANV - rotates Scanivalve and reads and records all HPDAS channels
     AT EACH PORT
          READ DATA
          RECORD DATA
JSCRD - called by JSCANV to read Scanivalve data
     READ DATA
     AVERAGE DATA
     RECORD AVERAGES and STANDARD DEVIATIONS
JSCPOS - called by JSCANV to position the Scanivalve
     CALCULATE POSITION
     CALL SCHOME AND/OR SCSTEP UNTIL DESIRED PORT IS REACHED
     AT CERTAIN PORTS ALONG THE WAY, SOME DATA IS STORED IN GLOBAL
          COMMON FOR USE BY DISPLAY PROGRAM
SCSTEP - moves Scanivalve to next port
          OUTPUT STEP COMMAND TO SCANIVALVE
          IF NEW PORT=1, CALIBRATE POSITION POTENTIOMETER
SCHOME - moves Scanivalve to HOME port
          IF POSITION=47, CALL SCSTEP TO GET TO PORT 0
          ELSE OUTPUT HOME COMMAND TO SCANIVALVE
```

STORE NEW FEEDBACK SO SCSTEP CAN CALIBRATE POT.

PCAL - calibrate close-coupled pressure transducers

LOG P-CAL

CHECK REFERENCE PRESSURES FOR INTEGRITY

MOVE P-CAL VALVES TO CALIBRATE POSITION

FOR SOLENOID VALVE POSITIONS 1, 2, AND 3

SET SOLENOID POSITION

WAIT FOR PRESSURE TO STABILIZE

ACQUIRE AND SUM 30 SAMPLES OF DATA

AVG DATA & RECORD

RECORD STANDARD DEVIATIONS

COMPUTE NEW CALIBRATION COEFFICIENTS FOR VARIABLES IN THE DISPLAY PROGRAM

MOVE VALVES BACK TO MEASUREMENT POSITION

PVMOVE - move PCAL valve to either "calibrate" or "measurement" position

CCHECK - perform HPDAS amplifier calibration

LOG CHANNEL CHECK

FOR LEVEL = 1,2

SET LEVEL IN HPDAS AMPLIFIERS

ACQUIRE AND SUM 100 SAMPLES

AVG DATA AND RECORD

RECORD STANDARD DEVIATIONS

COMPUTE NEW CAL. COEFFICIENTS FOR VARIABLES IN THE DISPLAY PROGRAM

SET AMPLIFIERS BACK TO MEASUREMENT POSITION

SCCAL - called during CAL mode to compute coefficient for variables in the display program that are calculated from Scanivalve data

MOVE SCANIVALVE TO PORTS 1, 2, AND 3

MEASURE REFERENCE PRESSURES AT THESE PORTS

CALCULATE COEFFICIENTS FOR EACH SCANIVALVE TRANSDUCER.

CMPCOEF - used for computing calibration coefficients

TSTSTAT - tests the status of all the data acquisition devices that this software controls. If a bad status is detected, it is flagged and displayed on the CRT, and TSTSTAT initiates a data abort if data is currently being recorded.

SET - Sets the HPDAS gains and filters and scan mode

RCDATA - records acquired data on disk. Two buffers used for output to disk. Each are blocked with with user records.

```
IF DISK IS FULL, RETURN
UPDATE BUFFER INFORMATION
IF BUFFER FULL
     WRITE IT TO DISK
     SWITCH TO OTHER BUFFER
     IF DISK FULL, SET MODE=DISK-FULL-MODE
INCREMENT BUFFER POINTER
RETURN
```

DTCOPY - copies disk data to magnetic tape

```
LOG DISK-TO-TAPE COPY
FOR EACH RECORD OF DISK DATA FILE
     READ RECORD FROM DISK
     WRITE TO TAPE
     PRINT INFO ON LOGGER FOR DOCUMENTING TAPE
WRITE FILE MARK ON TAPE
INITIALIZE GLOBAL COMMON
```

RUNOUT - writes unfilled buffer to disk before DTCOPY

AVERAGE - calculates averages and standard deviations of an array after successive calls

LABEL - reads in a label typed by the data engineer to describe the data

ENVBLK - reads in data bases from a directoried source file

READ DATA ACQUISITION SYSTEM DESCRIPTION DATA BASE FOR EACH RECORD

IF HPDAS CHANNEL, GET GAINS AND FILTERS

IF DISPLAY CHANNEL, COMPUTE CALIBRATION COEFFICIENTS

RECORD THIS RECORD

READ AND RECORD TEST ARTICLE CONFIGURATION DATA BASE

READ CLEARANCE CALIBRATION TABLES

FOR EACH RECORD

IF SEVENTH STAGE, CONVERT AND STORE TABLE FOR THE DISPLAY PROGRAM

RECORD THIS RECORD

CONVCLTB - converts clearance tables from ASCII to table format used by TBSRCH and TBLOOK routines

GNFILT - records new gains and filter codes and resets HPDAS amplifiers with them

FILBUF - fills data buffer with four 80-character records of text from disk databases

INIT - initializes variables and homes P-CAL valves

LOGPOINT - logs events on keyboard printer

PRINTCAL - prints calibration information of all HPDAS channels that are displayed on the CRT

B. J85CONSOLE TASK

J85CONSOLE - accepts operator commands, controls J85DAQ and displays data

INITIALIZE

ACTIVATE J85DAQ (DATA ACQUISITION TASK)

LOOP

COMPUTE AND DISPLAY DATA

PROCESS ANY COMMANDS

REPEAT

DISPLAY - display data on CRT

HEADING - output display headings on CRT

HARDCOPY - Copies display data to global common and activate hardcopy task

COMMAND - accepts operator commands and processes them

GET COMMAND

IF NOT A VALID COMMAND OR ILLEGAL DURING THIS MODE, TELL OPERATOR

ELSE PROCESS COMMAND

LEGAL - determines if command is legal during current mode

LABWAIT - relinquishes CRT to J85DAQ so operator can type in a label in LABEL Mode

TRCTRL - controls transient data acquisition modes

CASE C

C = TR: REQUEST TRANSIENT CAL-1

RETURN

C = GO: TRANSIENT CAL-1 COMPLETED, START TRANSIENT 1

C = NOCOMMAND: IF TRANSIENT CAL-2 JUST COMPLETED

START TRANSIENT 3

RETURN

IF TIME DURATION OR A TRANSIENT HAS

JUST COMPLETED

SET C = ADV

REPEAT CASE

ELSE RETURN

```
C = ADV:  IF MODE = TRANSIENT1, START TRANSIENT2
          IF MODE = TRANSIENT2, START TRANSIENT CAL-2
          IF MODE = TRANSIENT3, START STEADY-STATE MODE
          RETURN
```

GETCMD - read operator commands on CRT

```
     IF C = 0
          READ ONE CHARACTER IN QUICK RETURN MODE
          DELAY 1/2 SEC
          IF READ NOT COMPLETED
               TERMINATE READ
               RETURN
          ELSE
               READ THE REST OF THE LINE INTO BUFFER
               EXTRACT COMMAND FROM BUFFER
               PASS COMMAND TO CALLING ROUTINE
               RETURN
     IF C = 1
          EXTRACT TRANSIENT PARAMETERS FROM INPUT BUFFERS
          RETURN
```

CA2B - convert an ASCII character string to a binary number

SETGF - allows operator to change HPDAS amplifier gains and filters and to delete bad channels from future data reduction. This program only modifies a buffer in global common that J85DAC uses to actually change gains and filter in the HPDAS amplifiers.

GFIN - used by SETGF to read gain and filter modifications to be made

DELCHAN - used by SETGF to read channel numbers to be deleted

ACTPROG - uses MAXNET III task activate service to start up data acquisition hand hardcopy tasks

COMPUTE - computes all data to be displayed

K2BCD - converts a floating point number to BCD

RAW - prints uncovered HPDAS input data on display data for debug purposes

INIT - reads in thermocouple calibration tables

RDTTBL - reads a table from a directoried source file and converts each table entry from ASCII to floating point

TCALF - converts thermocouple millivolt readings to temperature units

LOOK UP IN THERMOCOUPLE TABLES TO GET MILLIVOLTS FOR REFERENCE TEMPERATURE

ADD REFERENCE MILLIVOLTS TO MEASURED MILLIVOLTS

SEARCH TABLE FOR TEMPERATURE FROM COMBINED MILLIVOLTS

CONVERT TEMPERATURE FROM DEG C TO DEG R

C. MAP TASK

MAP - main program to display compressor performance on a graphics CRT during test

```
LOOP
    AVERAGE PR AND MC FOR MAP
    READ COMMAND
    IF NO COMMAND
        IF DISPLAY FLAG-TRUE
            IF mode=TRANSIENT OR MONITOR
                PUT DOT ON SCRREN FOR THIS PR & MC1
    ELSE PROCESS COMMAND
                'S'=STOP
                'M'=DRAW BACKGROUND
                ' '=DISPLAY FLAG=NOT(DISPLAY FLAG)
    REPEAT
```

AVEMAP - averages pressure ratio and corrected mass flow over last five cycles

MAPPOINT - draws a point on screen for pressure ratio and corrected flow location

COMPMAP - draws a background compressor map for orientation of real time points

DASH - draws a dashed line on CRT; used by COMPMAP

LOCCUR - calculates CRT screen coordinates from engineering units.

FOUT - prints a floating point number of the CRT at a specified location in screen coordinates

D. HDCPY TASK

HDCPY - prints data from global common the same format as the A/N CRT display

REFERENCES

1. Modcomp MAX III Operating System Reference Manual, Rev K, 1979.

2. Modcomp I/O Reference Manual, Rev K, 1979.

3. Modcomp Systems Design Handbook, (no date).

4. B. Brownstein, Simulation of a Real-Time Multiprocessor Network, Wright State University Thesis, 1977.

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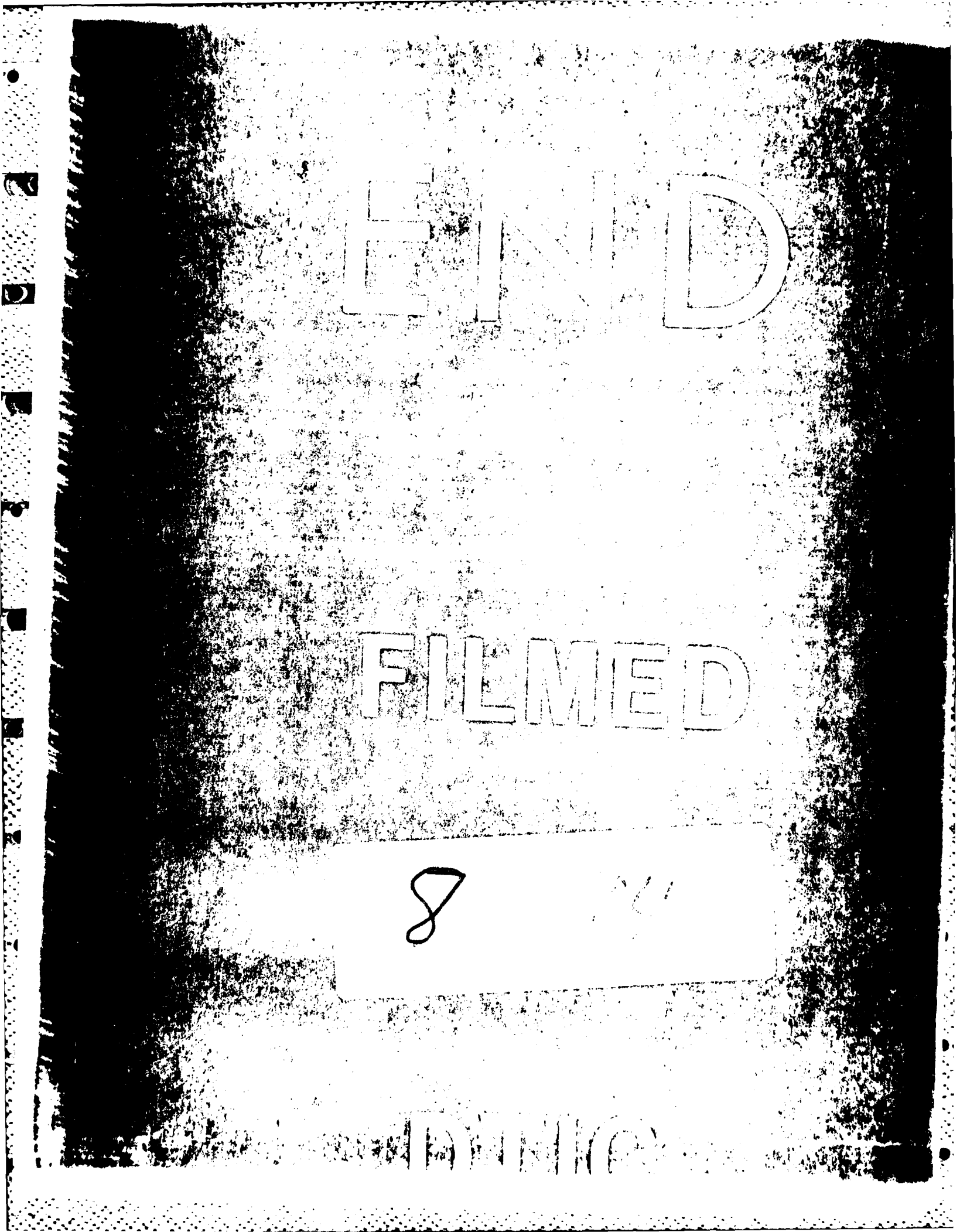
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